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STUDIES ON GENETIC VARIABILITY, CORRELATION AND PATH ANALYSIS OF SEED YIELD AND RELATED TRAITS IN GREEN GRAM [VIGNA RADIATA L. WILCZEK]

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ABSTRACT

An experiment was conducted on green gram to study the genetic variability, correlation among the yield components their direct and indirect effects on seed yield generating from the cross BL-865 × Chinamung in F_2 and F_3 generation to make effective selections. Highest GCV and PCV were observed for all the traits studied. On the basis of genetic variability study all the growth and yield traits exhibited high heritability estimates (broad sense) coupled with high genetic advance, indicating the preponderance of additive gene action. Hence, direct selection may be exercised for improvement of these traits. Phenotypic coefficient of variation was slightly higher in magnitude than the genotypic coefficient of variation. Number of pods per plant, pod yield per plant and threshing percentage had shown positive and significant correlation along with their high positive direct effect with seed yield, suggesting that these parameters may be considered as prime traits during the course of selection to have the higher potential of yield in green gram.

KEYWORDS: Green Gram, Genetic Variability, Correlation and Path Analysis

INTRODUCTION

Green gram (*Vigna radiata* (L) Wilczek) which is also known as mungbean, belongs to the family *Leguminaceae*, subfamily *Papilionoideae* with a chromosome number 2n=22 is a crop native to India cultivated since pre-historic period under rainfed situations for dry seeds. There is large disparity in yield of cereals and legumes. But as contrast to the impressive achievement in cereals, pulse production in our country remained almost stagnant with slight increase in productivity. In India, green gram is cultivated in an area of 34.4 lakh ha with production of 14 lakh tons and productivity of 638 kg/ha (Indiastat.com 2013). In Karnataka green gram is cultivated in an area of 5.28 lakh ha with production of 1.08 lakh tones and the average productivity of 205 kg/ha (Indiastat.com 2013).

Green gram is one of the important *kharif* and summer pulse of our country, which contains high quality and easily digestible protein 22-26 %. Since green gram is regularly grown under low rainfall conditions, cultivated in low fertility lands associated with frequent drought spells in addition to pest and diseases adversely affecting the yield and yield contributing traits and also lack of improved varieties coupled with poor availability of quality seeds, and narrow genetic base, the genes governing for agronomic characteristics responsible for high yield have been eroded from green gram like other marginal crops, which had relatively little value under the competitive and stress conditions of a primitive agriculture.

The entire success of plant breeding programme of any crop largely depends on the wide range of genetic

variability in respect of important economic characters present in the population upon which is based on the effectiveness of selection. Environment has a profound influence upon the economically important characters, which are quantitatively inherited. Hence, it is difficult to decide upon whether the observed variability is heritable or due to environment and it is therefore, necessary to partition the variance into its heritable and non-heritable components with suitable genetic parameters. Selection procedure is more difficult in a trait with low heritability. Indirect selection in such a situation is more effective and study of correlation among different economic traits are therefore, essential for an effective selection programme because selection for one or more trait results in correlated response for several other traits. Hence, the knowledge of phenotypic correlation between yield and its contributing characters is very essential. Path coefficient analysis has been found useful direct and indirect causes of association and allows a detailed examination of specific forces acting to produce a given correlation and measures the relative importance of each causal factor. This paper deals with the above aspects for seed yield and yield components in F_2 and F_3 generations of green gram.

MATERIALS AND METHODS

The present investigation was conducted at K-block, University of Agriculture Sciences, Bangalore during *kharif* 2013 and *summer* 2014. Geographically, the experimental site is located at an altitude of 899 m above mean sea level and 13 00°N latitude and 77 35°E longitude. With an average rainfall of about 846.9 mm.The soil type of the experimental block was red sandy loam with pH in the range of 6.5 to 7.5. The material comprised of cross BL 865 × Chinamung that was best performing with respect to seed yield and yield related traits was considered for the present study. F_2 population was evaluated along with parents and checks *viz* KKM-3, Chinamung for seed yield and yield contributing traits, selections were made from the cross based on mean performance of traits *viz.,* pods per plant, pod yield per plant, seed yield per plant and threshing percentage and F_3 generation was raised on plant-to-row progeny basis in an augmented design with 10 compact blocks. Each block comprised of genotypes, parental lines and check varieties. Each progeny was sown in single row of 3m length with a spacing of 30 cm between the rows and plant to plant distance of 10 cm. All recommended agronomic practices and plant protection measures were followed during the crop growth period to ensure better growth and yield. The observations were recorded on all F_2 and F_3 populations on individual plant basis on growth and yield contributing traits. Genetic parameters like mean, range, genotypic and phenotypic coefficient of variation, heritability, genetic advance as *per cent* mean, correlation coefficient and path coefficient analysis were calculated as per the standard procedure.

RESULTS AND DISCUSSIONS

The analysis of variance in F_3 progenies revealed highly significant ($p<0.01$) to significant ($p<0.05$) differences observed for all characters among the F_3 progenies. This suggested adequate amount of genetic variability found among F_3 progenies **(Table 1).**

Genetic Variability Parameters in F_2 Generation for 11 Quantitative Traits in the Cross BL 865 × Chinamung in Green Gram (Table 2).

Days to first flowering between F_2 and F_3 had a mean value of 32.74 and 32.78 days, ranging from 29 to 50 days, indicating high range of variability. The estimates of GCV (4.80, 3.85) and PCV (5.89, 5.15) were low. Indicating considerably lesser extent of genetic variation for this trait, limited scope of selection for this character.High to moderate heritability was recorded (66.35, 56.08) coupled with low genetic advance (8.02, 5.95) expressed as *per cent*

of mean.Indicating a narrow range of variability and the occurrence of both additive as well as non-additive gene action for this trait, these findings reported by earlier workers Venkateswarlu (2001) and Mallikarjuna Rao *et al.,* (2006).

Plant height between F_2 and F_3 with a mean value of 24.67 and 21.60cm, varied between 19.00 and 18.00 to 46.20 and 48.00cm.The estimates of GCV (27.10, 20.93) and PCV (30.04, 25.64) were high. Indicating large amount of variation, Broad sense heritability was high (81.39, 66.68) coupled with high genetic advance (50.23, 35.21) expressed as *per cent* of mean. Suggesting that this character was under the control of additive genes and phenotypic selection could be effective. These results are in agreement with the results obtained by Byregowda *et al.,* (1997) and Mallikarjuna Rao *et al.,* (2006).

Branches per plant between F_2 and F_3 with a mean value 1.48 and 1.10, ranging from 1 and 1 to 4 and 3.This variability was further assured by higher values of GCV (36.54, 24.42) and PCV (51.99, 29.04).That means less influence of environment on the expression of traits, which indicating that this trait offer scope for selection, reported by Mallikarjuna Rao *et al.,* (2006).Whereas moderate to high heritability was found (49.39, 70.69) with high genetic advance as *per cent* of mean (52.59, 42.29) was observed for this character. Indicating predominance of additive gene action and scope for improving this character through simple selection may be effective. This finding also get collaborated with Kamleshwar kumar *et al.* (2013).

Clusters per plant between F_2 and F_3 with a mean value 6.17 and 3.49, ranging between 1 and 1 to 35 and 15. This wide range of variability was further assured by higher values of GCV (76.29, 32.78) and PCV (80.89, 40.70).Indicating existence of greater genetic variability. Whereas heritability was found to be high (88.96, 64.88) with high genetic advance (147.88, 54.40) expressed as *per cent* of mean. Indicating preponderance of additive genes and scope for improving this character through simple selection may be effective. These results are in agreement with the results obtained by Sheela Mary and Gopalan (2006) and Kamleshwar kumar *et al.* (2013).

Considerable variation existed for pods per plant between F_2 and F_3 with mean a value of 11.92 and 7.19, varied from 1 and 3 to 49 and 41. It was further assured by higher values of GCV (76.27, 43.64) and PCV (80.88, 50.24) values,indicating existence of greater magnitude of genetic variability for this trait, selection is effective. Estimate of broad sense heritability was found to be high (88.92, 75.45) coupled with high genetic advance expressed as *per cent* of mean (147.80, 78.08). Indicating the predominance of additive gene action, scope for simple selection.This finding also get collaborated with Imdad Ullah Zaid (2012) and Kamleshwar kumar *et al.*, (2013).

Pods per cluster between F_2 and F_3 was observed with a mean value of 2.01 and 2.10, ranging from 0.29 and 0.63 to 6.13 and 8.20.The estimates GCV (35.94, 28.73) and PCV (45.30, 32.44) values were high. Indicating minor effect of environment on expression of this trait and large amount of variation was found. Broad sense heritability was high (62.95 and 78.41) coupled with high genetic advance (58.50 and 52.41) expressed as *per cent* of mean. These results are in agreement with the results obtained by Mallikarjuna Rao *et al.,* (2006) and Kamleshwar kumar *et al.,* (2013).

Length of pods between F_2 and F_3 with the mean value of 5.91 and 6.00cm, ranging from 4.06 and 4.06 to 7.60 and 8.10 cm .The estimates of GCV (10.3,3 9.22) and PCV (10.99, 11.26) registered moderate values. Considerably less amount of genetic variation was found for this trait. Broad sense heritability (88.50, 67.07) was high coupled with moderate genetic advance (19.98, 15.55) expressed as *per cent* of mean. Indicating that this trait was under the control of both additive and non-additive gene action, selection may not be effective, This finding also get collaborated with

Mallikarjuna Rao *et al.*, (2006) and Imdad Ullah Zaid (2012).

Seeds per pod between F_2 and F_3 had mean a value of 10.13 and 10.22, varied from 3 and 3 to 14.56 and 15.80, there was a high to moderate GCV (20.78, 17.01) and PCV (21.91, 20.99) was observed. Less variability was observed, Selection for this trait is less effective. High broad sense heritability (89.90, 65.68) and high genetic advance (40.49, 28.39) expressed as *per cent* of mean. This trait is under the control of both additive and non-additive gene action, selection may not be effective. This is on par with the studies of Sheela Mary and Gopalan (2006) and Imdad Ullah Zaid (2012).

Considerable variation was existed for pod yield per plant between F_2 and F_3 with a mean value of 4.95 and 2.19 g, ranging from 0.49 and 0.60 to 27 and 20.37 g. The estimates of GCV (83.63, 66.36) and PCV (100.09, 74.66) were high with broad difference between them.Indicates the existence of greater amount of genetic variability for this trait. High heritability (69.81, 78.99) coupled with high genetic advance as *per cent* of mean (143.43, 121.50) was observed for this character. Suggesting that this character was under the control of additive genes and scope for phenotypic selection for this character might be effective, reported by Byregowda *et al.*, (1997), Mallikarjuna Rao *et al.*, (2006) and Kamleshwar kumar *et al.* (2013).

Seed yield per plant between F_2 and F_3 with mean a value of 3.30 and 1.62g, varied from 0.20 and 0.30 to 20.57and 18.47 g. This trait exhibited high GCV (60.24, 79.54) and PCV (64.28, 86.41) value, indicated that the higher magnitude of variability was recorded. The estimates of the both the broad sense heritability (66.35, 84.73) and genetic advance (104.59, 150.83) expressed as *per cent* of mean were high. The trait was under the control of additive genes, scope for simple selection may be effective.This finding also get collaborated with Aqsa tabasum *et al*. (2010), Kamleshwar kumar *et al.* (2013) and Narasimhulu *et al.* (2013).

Threshing percentage between F_2 and F_3 recorded mean a value of 63.01 and 71.07, ranging from 14.33 and 8.24 to 93.90 and 94.75.This trait exhibited high GCV (27.68, 20.80) and PCV (30.04, 23.49) values. Existence of high amount of variability for this trait.The estimates of the both the broad sense heritability (81.39, 78.37) and genetic advance as *per cent* of mean (50.23, 37.93) were high. Suggesting that this character was under the control of additive genes and scope for simple selection may be effective, reported by Mallikarjuna Rao *et al.*, (2006) and Rozina Gul *et al.*, (2008).

Association Analysis for Yield and its Component Traits in F_2 & F_3 Generation of the Cross BL 865 × Chinamung (Table 3)

Seed yield per plant between F_2 and F_3 population exhibited positive and significant association with plant height, primary branches per plant, clusters per plant, pods per plant, pods per cluster, pod yield per plant, threshing percentage. Pod length and seeds per pod in F_2 population alone exhibited positive and significant association with seed yield. Similar results were also observed by Byregowda *et al.*, (1997), Mallikarjuna Rao *et al.*, (2006) and Kamleshwar kumar *et al.* (2013). Plant height between F_2 and F_3 population registered positive and significant association with branches per plant, clusters per plant, pods per plant, pods per cluster, pod yield per plant and threshing percentage. Which may be responsible to enhance the yield of green gram.This finding is collaborated with Kamleshwar kumar *et al.* (2013). Primary branches per plant between F_2 and F_3 population showed positive and significant association with clusters per plant, pods per plant and pod yield per plant. These finding was in agreement with the observations of Mallikarjuna Rao *et al.*, (2006). Clusters per plant between F_2 and F_3 population showed positive and significant association with pods per plant, pod yield per plant and threshing percentage.Indicating that this character may be responsible to enhance the yield. Similar results were also

observed by with the findings of Byregowda *et al.,* (1997), Mallikarjuna Rao *et al.,* (2006). Pods per plant between F_2 and F_3 population exhibited positive and significant association with pods per cluster, seeds per pod, pod yield per plant and threshing percentage.Indicating that this character may be considered as prime trait during the course of selection for enhancing the yield of green gram.This finding is in conformity with Byregowda *et al.,* (1997), Mallikarjuna Rao *et al.,* (2006), Kamleshwar kumar *et al.* (2013). Pods per cluster between F_2 and F_3 population exhibited positive and significant association with pod yield per plant, threshing percentage. Similar results were also observed by Aqsa tabasum *et al.* (2010) and Narasimhulu *et al.* (2013). Pod length between F_2 and F_3 population recorded positively significant relationship with seeds per pod.This results are collaborated with Venkateswarlu (2001). Seeds per pod between F_2 and F_3 population exhibited positive and significant association with pod yield and threshing percentage. This finding was in agreement with the observations of Rajan (2000), Rozina Gul *et al.,* (2008). Pod yield per plant between F_2 and F_3 population registered positively significant relationship with and threshing percentage. Indicating that this character may be responsible to enhance the yield.Similar results reported by Rajan *et al.,* (2000), Mallikarjuna Rao *et al.,* (2006), Kamleshwar kumar *et al.*(2013) and Narasimhulu *et al.* (2013).

Path analysis of seed yield per plant in F_2 & F_3 generations of the cross BL 865 × Chinamung in green gram (Table 4).

In order to understand the true significance of the correlation studies the highly correlated traits were subjected to Path coefficient analysis. Pod yield per plant between F_2 and F_3 population exhibited highest positive direct effect followed by pods per plant and threshing percentage. This result are in agreement with the results obtained by Venkateswarlu (2001) and Mallikarjuna Rao *et al*., (2006). Hence selection for these traits would greatly contribute towards enhancing seed yield per plant in green gram breeding.

Plant height had highest indirect effect on seed yield per plant *via* pod yield per plant followed by pods per plant. Primary branches per plant showed highest indirect effect on seed yield per plant *via* pod yield per plant followed by pods per plant. Clusters per plant highest indirect effect on seed yield per plant *via* pod yield per plant followed by pods per plant. Pods per plant had highest indirect effect on seed yield per plant through pod yield per plant followed by threshing percentage. Pods per cluster showed indirect effect on seed yield per plant *via* pod yield per plant followed by pods per plant. Hence priority should be given to these traits in indirect selection for seed yield improvement. Similar results are in conformity with the results of Kousar Makeen *et al.* (2007), Kamleshwar kumar *et al.* (2013) and Narasimhulu *et al.* (2013). Pod yield per plant exhibited highest indirect effect on seed yield per plant *via* pods per plant followed by threshing percentage. Threshing percentage showed indirect effect on seed yield per plant *via* pod yield per plant followed by pods per plant.Indicating that these characters may be considered as prime traits during the course of selection for enhancing the yield of green gram. Similar results were also observed by with the findings of Mallikarjuna Rao *et al.,* (2006), Kousar Makeen *et al.* (2007) and Kamleshwar kumar *et al.* (2013).

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APPENDICES

Table 1: Analysis of Variance for Growth and Yield Parameters in F_3 Generation of the Cross BL 865 × Chinamung in Green Gram

Source of Variation	D F	Mean Sum of Squares										
		Flowering	Plant Height(Cm)	Branches /Plant	Clusters/ Plant	Pods /Plant	Pods/ Cluster	Pod Length (Cm)	Seeds/ Pod	Pod Yield/Pl. (G)	Seed Yield/Pl. (G)	Threshing (%)
Blocks	1	0.002	5.54	0.001	0.15*	0.02	0.001	0.02	0.03	0.80*	525*	0.25
F_3 progenies + Checks	29	7.39*	102.06*	0.41*	1.67**	14.59*	0.78*	2.78*	3.19**	3.72**	2.77**	466.57**
Checks	3	15.52**	11.14	0.17	1.76**	24.13**	1.26*	3.45*	0.98*	8.52*	7.77**	30.99
F_3 progenies	25	6.69*	114.01*	0.45*	1.65**	11.14*	0.68*	2.77*	3.31**	3.21**	1.94**	455.54**
Checks vs F_3 progenies	1	0.30	76.18*	0.001	1.78**	72.18**	1.80**	1.17	6.73**	1.98*	8.69**	2048.84**
Error	3	0.43	4.69	0.02	0.01	0.76	0.04	0.15	0.08	0.06	0.03	6.70

* Significant @ P=0.05   ** Significant @ P=0.01

Table 2: Estimates of Mean, Range, Variability, Heritability and Genetic Advance as Per Cent of Mean for Growth and Yield Parameters in F_2 & F_3 Generations of the Cross BL 865 × Chinamung in Green Gram

Traits	Mean		Range				GCV (%)		PCV (%)		Broad Sense H^2 (%)		GAM (%)	
			Min		Max									
Generation	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
X1	32.74	32.78	29.00	29.00	50.00	50.00	4.8	3.85	5.89	5.15	66.35	56.08	8.02	5.95
X2	24.67	21.60	19.00	18.00	46.20	48.00	27.1	20.93	30.04	25.64	81.39	66.68	50.23	35.21
X3	1.48	1.10	1.00	1.00	4.00	3.00	36.54	24.42	51.99	29.04	49.39	70.69	52.59	42.29
X4	6.17	3.49	1.00	1.00	35.00	15.00	76.29	32.78	80.89	40.70	88.96	64.88	147.88	54.40
X5	11.92	7.19	1.00	3.00	49.00	41.00	76.27	43.64	80.88	50.24	88.92	75.45	147.8	78.08
X6	2.01	2.10	0.29	0.63	6.13	8.20	35.94	28.73	45.3	32.44	62.95	78.41	58.5	52.41
X7	5.91	6.00	4.06	4.06	7.60	8.10	10.33	9.22	10.99	11.26	88.50	67.07	19.98	15.55
X8	10.13	10.22	3.00	3.00	14.56	15.80	20.78	17.01	21.91	20.99	89.90	65.68	40.49	28.39
X9	4.95	2.19	0.49	0.60	27.00	20.37	83.63	66.36	100.09	74.66	69.81	78.99	143.43	121.50
X10	3.30	1.62	0.20	0.30	20.57	18.47	60.24	79.54	64.28	86.41	66.35	84.73	104.59	150.83
X11	63.01	71.07	14.33	8.24	93.90	94.75	27.1	20.80	30.04	23.49	81.39	78.37	50.23	37.93

X1: Days to first flowering, **X2:** Plant height (cm), **X3:** Branches per plant, **X4:** Clusters per plant, **X5:** Pods per plant, **X6:** Pods per cluster, **X7:** Pod length(cm) , **X8:** Seeds per pod, **X9:** Pod yield per plant(g), **X10:** Seed yield per plant(g), **X11:** Threshing percentage.

Table 3: **Estimates of Phenotypic Correlation Coefficients For Seed Yield and its Contributing Characters in F_2 & F_3 Generations of the Cross BL 865 × Chinamung in Green Gram**

Traits	G	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
X1	F_2	**1.000**	0.318**	0.495**	0.552**	0.227**	0.401**	0.374**	0.455**	0.138*	0.429**
	F_3	**1.000**	0.108**	0.517**	0.618**	0.259**	0.018	-0.040	0.387**	0.266**	0.445**
X2	F_2		**1.000**	0.747**	0.569**	-0.152*	0.291**	0.267**	0.440**	0.099	0.422**
	F_3		**1.000**	0.256**	0.210**	0.022	-0.072	0.018	0.130**	0.150**	0.156**
X3	F_2			**1.000**	0.782**	-0.104	0.379**	0.328**	0.631**	0.171**	0.616**
	F_3			**1.000**	0.715**	-0.164**	0.011	-0.079*	0.444**	0.350**	0.517**
X4	F_2				**1.000**	0.411**	0.368**	0.347**	0.700**	0.241**	0.698**
	F_3				**1.000**	0.505**	0.003	-0.078*	0.684**	0.395**	0.766**
X5	F_2					**1.000**	0.081	0.133*	0.199**	0.141*	0.212**
	F_3					**1.000**	0.005	- 0.018	0.351**	0.140**	0.377**
X6	F_2						**1.000**	0.716**	0.443**	0.259**	0.443**
	F_3						**1.000**	0.327**	0.017	-0.027	0.004
X7	F_2							**1.000**	0.421**	0.213**	0.425**
	F_3							**1.000**	-0.020	-0.095*	-0.072
X8	F_2								**1.000**	0.204**	0.957**
	F_3								**1.000**	0.256**	0.886**
X9	F_2									**1.000**	0.401**
	F_3									**1.000**	0.540**
X10	F_2										**1.000**
	F_3										**1.000**

X1: Plant height (cm), **X2:** Branches per plant, **X3:** Clusters per plant, **X4:** Pods per plant, X5**:** Pods per cluster, X6**:** Pod length (cm), **X7:** Seeds per pod, **X8:** Pod yield per plant (g), **X9:** Threshing percentage, **X10:** Seed yield per plant (g).

Table 4: Estimates of Direct Effects (Diagonal) and Indirect Effects of Different Characters on Seed Yield Per Plant in F_2 & F_3 Generations of the Cross BL 865 × Chinamung in Green Gram

Traits		Plant Height (Cm)	Branches /Plant	Clusters/ Plant	Pods /Plant	Pods/ Cluster	Pod Yield/Pl.(G)	Threshing (%)	Seed Yield/Pl.(G) (R)
Plant height(cm)	F_2	**-0.024**	-0.003	-0.001	0.021	-0.002	0.415	0.030	**0.429****
	F_3	**-0.010**	-0.001	-0.073	0.212	-0.025	0.262	0.079	**0.445****
Branches/Plant	F_2	-0.007	**-0.011**	-0.001	0.021	0.001	0.401	0.021	**0.422****
	F_3	-0.001	**-0.010**	-0.036	0.072	-0.002	0.088	0.045	**0.156****
Clusters/ plant	F_2	-0.011	-0.008	**-0.001**	0.029	0.001	0.575	0.037	**0.616****
	F_3	-0.005	-0.002	**-0.141**	0.245	0.015	0.300	0.104	**0.517****
Pods /plant	F_2	-0.013	-0.006	-0.001	**0.038**	-0.005	0.638	0.052	**0.698****
	F_3	-0.006	-0.002	-0.101	**0.343**	-0.048	0.462	0.118	**0.766****
Pods/cluster	F_2	-0.005	0.001	0.001	0.015	**-0.012**	0.181	0.030	**0.212****
	F_3	-0.002	-0.001	0.023	0.173	**-0.096**	0.237	0.042	**0.377****
Pod yield/pl.(g)	F_2	-0.011	-0.005	-0.001	0.026	-0.002	**0.911**	0.044	**0.957****
	F_3	-0.004	-0.001	-0.062	0.235	-0.033	**0.676**	0.066	**0.886****
Threshing percentage	F_2	-0.003	-0.001	-0.001	0.009	-0.001	0.186	**0.216**	**0.401****
	F_3	-0.002	-0.001	-0.049	0.136	-0.013	0.173	**0.298**	**0.540****

RESIDUAL EFFECT (F_2) = 0.1949 RESIDUAL EFFECT (F_3) = 0.2015